ENVIRONMENTAL ASSESSMENT OF THE NONQUITT SALT MARSH

BASELINE DATA ON TIDE REGIME, PROFILES, VEGETATION, WATER CHARACTERISTICS AND UTILIZATION BY WILDLIFE

Final report submitted to the Nonquitt Association

by

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TABLE OF CONTENTS

INTRODUCTION

The salt marsh at Nonquitt in South Dartmouth, Massachusetts suffered a 60% die-back in vegetation in the late 1970's due to the clogging of the culvert which connects the salt marsh to the bay (Sears & Parker 1981). The obstruction was not cleared for several months, apparently stressing the vegetation, primarily *Spartina alterniflora* (salt marsh cordgrass), beyond recovery.

Although there has been some regeneration, particularly in areas where *S. alterniflora* was transplanted (Parker & Sears 1982; Sears & Parker 1983), the majority of the denuded peat banks remain unvegetated except for sporadic patches of *Salicornia europaea* (glasswort), *Eleocharis parvula* (dwarf spikerush), blue-green algae which mats the surface.

Metcalf & Eddy (1983), found that interstitial soil salinities were so high that recolonization of the salt marsh by *Spartina* was precluded despite subsequent maintenance of flow through the culvert. They listed three recommendations in order to improve the unsatisfactory hydraulic conditions which exist at the culvert and channel. Their alternatives included:

1. The installation of a precast concrete box in lieu of the riprap section.
2. Removal and replacement of the existing riprap.
3. Replacement of the open channel with a piped system.

No action has been taken in this regard, however. Our study provides baseline data which will describe the historical and present condition of the marsh, and which can be used to develop an appropriate management plan for this system. Therefore, the following factors have been investigated:

1. History of the salt marsh, focussing on changes since the original inlet and channel were replaced by a culvert;
2. Production of a base map showing present condition of the marsh;
3. Tidal regime in the salt marsh compared to that in the bay;
4. Elevation profiles of the culvert, channel and salt marsh, and volume of tidal water entering the salt marsh;
5. Water chemistry in the marsh, specifically salinity, dissolved oxygen, pH and total alkalinity;
6. Current species distribution and abundance of vegetation in the salt marsh; and
7. Utilization of the salt marsh by shorebirds and waterfowl, and description of other wildlife observed in the marsh.

METHODS

Study Area. Sears & Parker (1981, 1985) provide a thorough description of the marsh at Nonquitt, discussion of salt marsh values and functions, and a chronology of events which led to its present condition. Little has changed in the past eight years. Most of the the marsh remains devoid of rooted vegetation. Our study is confined to the area within the shrub/woodland border which encircles the marsh.

History. Old photographs and maps were examined to determine changes in the marsh and location of the inlet since 1781, the earliest available detailed map. Also, personal communication with residents and examination of old photographs and historical accounts were assimilated into this report.

Base map. A map depicting the major wetland types was traced from vertical aerial infrared photographs (1"=1000') taken in March, 1987 by Sewell Co. for the Town of Dartmouth. The delineated wetlands are those identified and drawn by Ralph Tiner who, under contract to the town, mapped all the wetlands in Dartmouth. The locations of transects, water sampling stations, tide staffs and zones were overlaid on a base map adapted from the map produced by Sears & Parker (1981) on which the creeks and mosquito ditches are drawn.

Tidal regime. The tidal regime through a full tidal cycle was measured on August 5 (a predicted mean tide) and August 29, 1988 (a predicted high spring tide). Tide staffs were set up in the bay, about 25 meters from the mouth of the culvert (=pipe), and at three sites in the marsh (Figure 1). Tide levels were recorded every 20 minutes at each of the tide staffs and in the channel at the west mouth of the culvert and on the west side of the bridge.

Water levels and volume of flow. During the tidal regime studies, the volume of flow was determined by measuring the velocity of water entering/exiting the west mouth of the culvert every 20 minutes. Volume of flow was determined by using a digital flowmeter and then multiplying the measured velocity by the cross-sectional area of the culvert (Table 1). Total volume of flow into or out of the culvert was calulated as the sum of the average flow between each 20 minute sampling period for each direction. Calculations were carried out using Lotus 1-2-3 on an IBM-PC.

On November 9, the volume of water entering the channel at the west mouth of the culvert compared with the volume passing under the bridge (measured on the west side of the bridge) was similarly calculated (Table 1).

Water levels in the marsh were monitored throughout the tidal regime studies and at weekly intervals (minimum) thereafter. Readings were taken at tide staff, S1, until the pond froze, then readings were taken in the channel on the west side of the bridge. Permanent benchmarks were established and tied in to actual low water on the bay tide staff reading on August 5, 1988 (an approximate predicted mean tide). Low water was assumed to be 0.0 feet on that day and all elevations in this report are relative to this value.

Profiles of the channel and salt marsh. Profiles were measured for the following transects:

- from the east mouth of the culvert to the west mouth, through the channel at the deepest points and across the flood tidal delta,
- four cross-sectional transects of the channel between the west mouth of the culvert and the bridge,
- the length of the creek, and the former channel
- a representative cross-section of the pond west of the flood tidal delta, and
- seven transects across the exposed peat and vegetated portion of the salt marsh.

As for the tide staffs in the marsh, all values are relative to an assumed low water of 0.0′ on August 5. Profiles of the marsh and channel transects were measured by rod and transit. Within the pond, creek and other open water areas, depth of water was measured and tied in to one of the marsh tide staffs, which are tied in as previously described.

Water characteristics. Eight sampling stations were established and monitored on a weekly basis (Figure 1). Salinity was measured with an Atago S-10 refractometer and reported in parts per thousand (ppt). Dissolved oxygen was measured in parts per million (ppm) using a Lamotte kit. Total alkalinity and pH were measured with a HACH kit.

Vegetation. Twenty-five transects were randomly established throughout the salt marsh, twenty along the long axis of the marsh extending west from the head of the dredged inlet, and five along the short axis of the marsh which parallels South Road (Figure 1). The location for the transects was determined by measuring the total length of the two main creeks and then obtaining distances from a random numbers table between one and the total lengths of each creek. The transects were established appproximately perpendicular to the general course of the creek at each site, and extended from the edge of the creek to the shrub border which encircles the entire marsh. Stations were established at five-meter intervals, beginning at one meter in order to avoid the edge of the creek. Five-meter subtransects at each station extended perpendicular to the transect randomly east or west (or north or south) of the transects, the direction being determined by a coin toss.

The vegetation was sampled at each meter interval along the subtransects with a $0.25M^2$ quadrat divided into twenty-five equal squares by recording the number of squares in which each species appeared. In addition to vegetation, unvegetated peat, mud and open water were also counted. In areas dominated by cattail or reeds, a visual estimate of percent cover was recorded and subsequently converted to number of squares. This was done because of the height of this vegetation precluded locating the quadrat in such a way as to obtain an accurate count of the squares directly. Data was entered on to an IBM-compatable AMDEK 88 and analyzed using SYSTAT 3.0 statistical package.

Wildlife. A census of birds utilizing the salt and fresh marsh, unvegetated peat and mud, and open water within the Nonquitt marsh was conducted at weekly intervals from July 19 to November 8, 1988, then biweekly from November 21, 1988 to March 27, 1989. The marsh was divided into three zones (Figure 2) and all birds which could be seen were counted from three sites or "platforms" (one within each zone), with habitat and activity recorded. The east and south sections of marsh were traversed on foot and the above data were also collected for birds not seen from the platforms. The transition from the marsh to shrub border surrounding the pond marked the boundary of the census area.

Habitats were identified as the following:

-open water (includes the channel, creeks and ditches, as well as the ponded areas within the marsh. Thus this area changes in size depending upon whether or not the peat is flooded.)

-exposed peat/mud (includes all unvegetated, exposed peat, mud or macroalgal mats)

-salt marsh (habitat dominated by salt marsh cordgrass or salt hay)

-fresh marsh (habitat dominated by sedges, asters, ferns and other fresh water wetlands vegetation)

-cattail/reed marsh (habitat dominated by these two species)

-shrub (habitat containing shrubs where bird is located within the sbrubs, even if shrubs are not the dominant vegetation)

-ice (frozen areas covering either the open water or exposed peat habitats)

-other (includes overhead or flushed birds as well as birds from unknown habitats)

As with the vegetation, data were analyzed using SYSTAT 3.0.

RESULTS

History

The reproduction of the 1781 Chart of Buzzards Bay originally produced for the British Admiralty depicts a creek flowing into the bay at the site of the Nonquitt marsh (Des Barres, 1781). However, the earliest map depicting the Nonquitt marsh in detail is the 1856, "Map of the Town of Dartmouth" produced by H.F. Walling (Figure 3). The excellent detail outlines the area of marsh surrounding "Barekneed Creek" which flowed into the bay just south of Barekneed Rocks (approximately 1500 feet north of the present man-made channel). The depicted boundary of the marsh is not substantially different from the current border (Figure 4) of the marsh despite the relocation of the inlet, with the exception of the west end of the marsh, which appears to have succeeded to a deciduous shrub swamp.

The maps of the Nonquitt marsh on the 1871 and 1895 Bristol County Atlases and the 1904 Atlas of Massachusetts depict only the creek and inlet, but not the marsh. The 1871 and 1904 renditions of the creek are virtually identical to the 1895 version presented here (Figure 5). The poor detail leaves little to be said about the marsh, but the inlet appears to be in the same location as it was in 1856. The 1885 U.S. Geological Survey topographic map shows the marsh, creek and inlet in good detail, essentially unchanged from the 1856 depiction.

However, according to Lyell (1987), sometime between 1872 and 1884,

"Job Anthony granted permission to the Nonquitt Beach & Wharf Association to move the outlet to its present location (Otter Creek) under an oral commitment from the Association to maintain it. Neither the Association nor its successor, Nonquitt Real Estate Trust, however, fully recognized this obligation, and often the outlet was kept fully open only by volunteering South Nonquitters. In 1922, ...the executive committee had not authorized any funds to unclog the outlet..."

The location of this new outlet was submitted to the Bristol County Registry of Deeds in 1883 (Figure 6), but the 1895 and 1904 maps show the Barekneed Creek with its orginal channel. Also, an 1887 photo in Lauderdale (1972), page 7, shows a wide creek following its original course in front of the houses on the point. With the problems associated with periodic clogging of the new outlet, the original channel and inlet may have been intermittently active at least until 1922. Then in 1938 and again in 1954 the barrier beach was breached by storm waves from the 1938 Hurricane and Hurricane Carol respectively, temporarily opening the old inlet and an inlet midway between the man-made and original inlets. Evidence of the temporary inlets appear on an aerial photograph dated December, 1938 (Lyell, 1987). The man-made channel and inlet also show up clearly on this photo.

Three sets of aerial photographs were inspected at the Taunton office of the U.S. Soil Conservation Survey (Bristol County

Division). Black and White photographs (scale 1":1667') from 1952 and 1971 as well as 1984 color infrared photos (scale 1:25,000) were observed for changes in the Nonquitt marsh since installation of the pipe and new channel. All interpretation was done with a 2X lens stereoscope.

Photos taken on 18 August 1952 show a very small flood tidal delta forming at the head of the inlet which may very well have been vegetated with Spartina. There is also evidence of an extensive vegetated marsh where brackish marsh, Typha marsh and unvegetated peat occur today. No detectable evidence of Phragmites encroachment onto the marsh exists up to this point. The mosquito ditching pattern on the marsh which exists today is evident at this time.

A small but growing flood tidal delta is shown on photos examined for 14 July 1971. Although the flood tidal delta was comparitively a bit larger than it was in 1952, it was still smaller than the present-day and 1984 delta. Curiously, the 1984 photo shows two channels cutting through the delta while this was not seen in 1952, 1971 or during our study (Summer - Fall 1988). With the exception of the 1984 photo, the only observable channels for water to flow past the delta were around each side of it. According to Sears and Parker (1981), the channel was dredged in the fall of 1981. Whether this is the cause of the double channel or not is uncertain. No evidence was seen in the 1971 photo of the Typha marsh which currently exists in the southern part adjacent to the Walsh residence. Based upon this photographic evidence, the area currently consisting of unvegetated peat was apparently vegetated at least up to 1971.

Also, it is interesting to note that in 1952, a small ponded a ea existed at the northern e ' of the marsh across from the road. In 1952 it had ditches radiating from it but they were flooded up to their most landward extent. Ho er, the 1984 photo and present field observations shows that this area has filled in with silt. It is also obvious in the 1984 photo that Phragmites occupied the current circular patch at the same site where it exists today.

Review of these aps and photographs suggests that at least until 1971, the pipe provided sufficient flow and drainage so that vegetation persisted across all areas of peat, areas historically vegetated. Numerous problems associated with either clogging of the new inlet or overwash and breaching of the barrier beach during hurricanes have impacted this marsh since construction of the new inlet, but apparently these did not cause any massive die-back in vegetation for most of this century. There is, however, some evidence of changes in species composition, particularly colonization by Typha and Phragmites, which indicates a change in the salinity regime of the marsh.

The die-back in the marsh, predominantly vegetated by Spartina, appears to have been taken place over a short period of time, precipitated by a series of storms and intermittent clogging of the channel since 1977. Sears & Parker (1981) present a chronology of blockage of the culvert due to a series of storms from November, 1977 to the October, 1980 storm. By the time of the October 25, 1980 storm which blocked the entire length of the culvert, nearly two-thirds of the marsh had suffered die-back (Sears & Parker 1981). Irregular and often long-term waterlogging apparently was the cause of the demise of the vegetation, and the negative effects associated with this waterlogging including oxygen depletion in the sediments and high soil salinity has prevented recolonization (Sears $ Parker 1981, 1985).

However, it cannot be stated that alteration of flow since the construction of the new channel was not having a significant impact upon the marsh prior to this event. The breaching of the barrier beach and opening of new inlets during both the 1938 and 1954 hurricanes and continuous problems with blockage of the culvert dating back to the time of installation are evidence that the marsh has not been in an equilibrium state with respect to the location and/or size of the man-made inlet. Also, restriction of flow associated with construction of the rip-rap in the channel between the culvert and bridge in 1962 may have contributed to the die-back (Metcalf & Eddy 1983), but to what extent is uncertain.

Tide regime

The tidal cycle for the bay, west mouth of the culvert and east and west sides of the bridge on August 5 and August 29, 1988 are graphed in Figures 7 & 8. The high, low, range and lag for the water levels in the marsh compared with the bay were as follows:

August 5, 1988 (0700) - August 6, 1988 (0220)

	Elevation (feet) of water level			
Station	Low water(time)	High water(time)	Low water(time)	Range
Bay	0.0 (0700-0740)	+3.9 (1440)	+0.5 (2140)	+3.9 +3.4
Culvert	+2.1 (0840-1220)	+3.4 (1420-1520)	+2.1 (2320)	+1.3 +1.3
Bridge(east)	+2.6 (1220)	+3.4 (1440-1520)	+2.6 (0400-0200)	+0.8 +0.8
Bridge(west)	+2.7 (0940-1300)	+3.0 (1440-1640)	+2.7 (2400-0220)	+0.3 +0.3

S1	+2.7 (0720-1320)	+3.0 (1620)	---	+0.3
S2	+2.6 (1000-1340)	+2.8 (1420-?)	---	+0.2
S3	+2.6 (?-1420)	+2.9 (1540-1720)	---	+0.3

August 29, 1988 (0305 - 2150)

Station	Low water(time)	High water(time)	Low water(time)	Range
Bay	-0.5 (?-0320)	+5.1 (0950)	-0.4 (1510-1630)	+5.6 +5.5
Culvert	+2.8 (?-0730)	+3.9 (0910-1050)	+2.7 (1850-1950)	+1.1 +1.2
Bridge(east)	+2.9 (?-0330)	+3.9 (0930-1030)	+2.9 (1850-1950)	+1.0 +1.0
Bridge(west)	+3.2 (?-0810)	+3.4 (0930-1010)	+3.1 (1410-1510)	+0.2 +0.3
S1	+3.2 (?-0910)	+3.4 (1010)	+3.1 (1630-1650)	+0.2 +0.3
S2	+3.0 (0830-0850)	+3.2 (1030)	+2.9 (1550-1810)	+0.2 +0.3
S3	+3.1 (?-1010)	+3.2 (1030-1630)	+3.1 (1650-?)	+0.1 +0.1

There was a 67% reduction in the tide range between the bay and the west mouth of the culvert on August 5, and a 78% reduction in the tide range on August 29, 1988. The bottom lip of the west mouth of the culvert is at an elevation of +1.5' and this, combined with the friction of the culvert, is responsible for the reduction.

On August 5, there was a 38% reduction in range from the culvert to the east side of the bridge (due entirely to a higher low water level at the bridge), but there was no reduction on August 29. The rip-rap 10 meters west of the culvert was likely the major cause of the reduction on August 5.

There is an 80% reduction in range between the east and west sides of the bridge on August 5 and a 63% reduction on August 29. This is due primarily to a stone obstruction under the bridge and the constriction of the channel at the bridge. Looking west through the opening under the bridge, the "head" created by this obstruction and constriction is obvious during the outgoing tide. The differences in the percent reductions between August 5 and August 29 reflect the different tidal amplitudes on these two days.

There is little or no difference between the tide range at the west side of the bridge and throughout the pond, except at S3 on August 29. Tidal fluctuation is fairly constant throughout the open water in the salt marsh, but the range has been dramatically reduced to 0.3 feet at S1 on both dates. The tidal range in the marsh is less than 10% of the tidal range in the bay. The reduction is even more dramatic during spring tides in the north end of the marsh where the range on August 29 was only 0.1'.

Water levels and volume of flow.

The total volume of water entering, then exiting the culvert at its west opening was calculated by measuring the volume of flow at 20 minute intervals during the tide regime studies (Table 1). The volume of water entering the culvert and entering the marsh at the bridge was similarly calculated on November 9, 1988. The results are as follows:

	CULVERT		BRIDGE		
	Volume IN	Volume OUT	Volume IN	High tide in the Bay	
	(volumes in cubic meters)			actual	predicted
5 Aug	3891	2522	--	+3.9′	+3.6′
29 Aug	5846	10,038	--	+5.1′	+4.8′
16 Nov	2981	--	2173	--	+2.9′

As might be expected, the higher the tide, the greater the flow into the marsh. The flow out of the culvert, however, is also related to the previous water level in the marsh, groundwater and/or rainwater entering the marsh and the constriction at the bridge. The higher the water level in the marsh, regardless of source, the greater the volume of flow out of the marsh.

On November 16, the volume which flowed through the culvert and entered the channel was 808 m^3 greater than that entering the marsh west of the bridge. This is due partly to the elevation of the rip-rap, but mostly to the obstruction at the bridge which creates a higher water level in the marsh throughout outgoing tides. The next incoming tide must reach the eelevation of the water on the west side of the bridge before flow is reversed into the marsh.

Water levels in the marsh have been monitored from August 5 to April 18 and are graphed on Figure 9. The formation of ice precluded monitoring water levels at the tide staffs from December 15, 1988 through February 14, 1989; however, the condition of the unvegetated peat was recorded as flooded, partially flooded or exposed during this period. After February 14, the water level was measured in the channel at the west side of this bridge. Results obtained during the tide regime study documented that water levels at tide staff, S1, and the west side of the bridge were for the most part equal.

The total range in water level through the study period at S1 wass 1.3′ (2.6′-3.9′). The mean water level in the marsh was 3.07′ or roughly 3.1′. A total of 58 readings were taken. Of these, the marsh was exposed 48% of the time (Figure 9). The unvegetated peat was flooded (31%) or partially flooded (21%) over half the time (52%). Of crucial importance is the fact that the periods when the unvegetated peat is flooded or partially flooded are clumped around the time of spring tides and/or moderate to heavy rainstorms (Figure 9). During these events the marsh may be flooded for several days in a row. Then as the water recedes, pools trapped in depressions in the exposed peat evaporate (particularly in the summer), concentrating salt on the peat at levels toxic at least to Spartina.

Profiles of the channel and marsh

Profiles of the inlet and channel were measured by rod and transit from August 5, 1989 through September 28, 1988. Figure 10 depicts the profile of the culvert and channel to a point just west of the flood tidal delta. The bed of the channel is generally at or below the elevation of the lower lip of the west end of the culvert with exceptions at the rip-rap, bridge and flood tidal delta. The latter is composed of silt and a high percentage of organic matter which is partially suspended in the water column. Evidence from the tide regime studies suggests that presently, the delta is not a major factor in reduction of tide range in the marsh. However both the rip-rap and the constriction at the bridge play a role in the reduction, particularly to the outgoing flow, of the water level in the marsh.

Figure 11 depicts a generalized cross-section of the open water ("pond") west of the flood tidal delta. The channel cuts through the northern side of the pond which gradually shallows towards the south side.

The creek which extends west from this pond to the upper reaches of the marsh was profiled on November 9, 1988 (Figure 12) by measuring the water depths at the end of each vegetation transect as far as could be reached by canoe. At this time, water levels in the former channel and open water in the northern section of the marsh were also measured (Figure 13). The deepest areas of the creek and ponded areas were about +1.0′ or less. Thus beds of all creeks and open water are at least a foot or more above mean low water in the bay.

Four cross-sectional profiles were taken across the channel between the bridge and culvert on September 27, 1988 (Appendix I, Figures 1-4). Figure 2 crosses the rip-rap, which is about 0.5′ above the lower lip of the culvert. The remaining profiles depict a channel which is at or lower than the culvert.

Seven of the vegetation transects were profiled from October 6 to November 4, 1988 (Appendix II, Figures 1-7). The mean elevation of the exposed peat was the same as mean water level (3.1′) in the marsh, and the vegetated portion was only slightly higher (Table 2).

Water characteristics

Salinity (Appendix III, Figures 1-8), pH (Table 3) and water temperature (Figure 14) have been measured throughout the study, while total alkalinity (Table 4) and and dissolved oxygen (Table 5) were sampled from fall to early winter.

Salinity was only slightly reduced at all but the uppermost stations until late October. Rainfall then restored flow to the fresh water streams entering the marsh and also most likely increased groundwater flow into the marsh resulting in a more typically esturine condition. Station 8 (Figure III-8), the upper end of the west creek, has remained nearly fresh since early November, while salinity in the west and north creeks (Stations 4-7; Figures III-4 - III-7) fluctuated dramatically since October (0-32 ppt) often with extended periods of very low salinity (less than 8 ppt). The drops in salinity coincide with moderate (>0.5") rainfall, while the peaks coincide with spring tides, particularly the new moon tides. However, from late October, 1988 to mid-April, 1989, the fresh water input due to rainfall appears to be the major source of water in the marsh. Peaks of salinity around spring tide do not nearly reach the salinity in the bay (Figure III-1) as was the case in September, and these peaks are of short duration compared with the intervening periods of low salinity. The salinity at Stations 2 & 3 (Figures III-2 & III-3) is more closely related to the direction of flow through the channel, being more saline on the incoming flow and fresher on the outgoing flow.

PH generally ranged from 7-8.5 throughout the marsh until early November when the pH first at Station 8, then stations 4-7 began to decline (Table 3). From January to April, 1989, the 6.5 readings may have been even lower, but the high range HACH pH kit only measured down to 6.5 (Chemicals for the low range kit had been used up in December). Values for total alkalinity also followed this trend (Table 4). Salt water has a relatively high buffering capacity, but with an increase in the importance of precipitation, which in this area can have pH readings between 4-5, this can clearly be the cause of the lowered pH regime in the marsh. Stations 2 & 3 do not reflect this drop as they are regularly inundated with sea water during each tidal cycle.

Dissolved oxygen has been near saturation levels throughout the study at all stations (Table 5), with the exception of Station 8, which had several readings below 4 ppm. There is no correlation with rainfall, but the expected correlation with water temperature (Figure 14) does not seem to be evident. As temperature drops, its capacity to hold dissolved oxygen increases, but this trend is not consistantly supported by the data. Nevertheless, the dissolved oxygen values from September, 1988 through January, 1989 indicate that at least through this period, oxygen demand is not abnormally high and organic pollution does not appear to be a major problem.

Vegetation

From August 9 to October 11, 1988 vegetation was surveyed for a total of 1,970 samples. The data are presented by frequency of occurrence of each species per sample (Table 6) and by relative abundance, which is the number of squares counted for each species divided by the total number of squares for all species (Table 7). Each station has been assigned a community (Table 8) based upon the dominant feature or species of each community, as follows:

1) Unvegetated Peat, which also includes mud and the algal mat (67% of all stations),
2) Spartina alterniflora (6% of all stations),
3) Spartina patens (9% of all stations),
4) Typha angustifolia, including Phragmites (8% of all stations, and
5) Fresh Marsh, dominated by Scirpus (10% of all stations).

Of the total number of squares in the 1,970 samples (1,970 samples X 25 squares/sample = 49,250), 29,976 were either unvegetated, covered by the algal mat or in shallow water such as flooded pannes. This represents nearly 61% of the total, the same precentage as was calculated from aerial photography by Sears & Parker (1981) as the area of die-back of the marsh. Overall, it appears that the marsh has not continued to degenerate, but neither has it significantly improved. However, for the purpose of defining communities, 264 out of 394 stations (67%) were identified as the unvegetated peat community; but many of these stations were not completely devoid of vegetation, as Eleocharis parvula, a tiny sedge colonizing both regularly and irregularlty flooded saline soils (Tiner, 1987), has formed some moderately large mats on the exposed peat, especially in the upper reaches of the marsh.

As previously mentioned, the mean elevation of the exposed peat is equal (to the nearest 0.1') to the mean water level in the marsh, 3.1' (Table 2). The mean elevation of the Spartina alterniflora and the S. patens communities are equal (3.36') and slightly lower than the mean elevation of the Typha community (3.41'). The fresh water community had a somewhat lower mean elevation (3.26'). Analysis of variance (Table 2) indicates that the differences in elevation among the five identified marsh communities is significant. It is the lower mean elevation of the exposed peat community that explains the significance among mean elevations of the marsh communities.

The Unvegetated Peat "community" is colonized by a scant amount of vegetation. Both Eleocharis parvula and Salicornia europaea are found in roughly 15% of the samples (Table 6), but Eleocharis is twice as abundant (# squares = relative amount of cover) as the Salicornia (Table 7). Some of the Salicornia in this community had recently died (apparently some time in late July or early August), presumably as the result of previous flooding and/or subsequent evaporation creating toxic saline soil. Of the 36 samples within this community containing Salicornia, 34 or roughly 94% contained dead plants. Half of the total number of squares counted for Salicornia were of dead plants (113 out of 227).

A curious feature of both the Spartina alterniflora and S. patens community is the abundance of species (purple loosestrife, seaside goldenrod, saltmarsh fleabane, three-square sedge, etc.) not generally considered to be tolerant of regular flooding by seawater. These species are more typical of the border between salt marsh and fresh marsh or upland. This suggests that at the present boundary between the vegetated and unvegetated segments of the marsh, there is not only a significant change in elevation (Mean = 3.4′ versus 3.1′), but also a significant change in the salinity regime both in the water and at soil level.

Of the vegetated portion of the marsh (130 stations), 72 or roughly 55% are dominated by Typha, Phragmites or fresh water marsh (Table 8). Fresh marsh vegetation is predominant in the vegetated marsh from Transect E westward along the southern side of the marsh. This suggests that rainwater/groundwater are major components of the tidal prism at least within the vegetated zone of the marsh. It should be noted that deleterious effects of salt water flooding were observed on at least Scirpus paludosus, where 26% (341 out of 1287 squares) were recently killed plants. These were clumped in depressions which in general were near the unvegetated peat in the mid- to upper (Transects H-K) reaches of the marsh.

Wildlife

Birds. From July, 1988 through March, 1989, sixty-six species of birds were identified during the censuses in the Nonquitt salt marsh, the major classes being waterfowl (32.5%), shorebirds (31.5%) and gulls (28%). These groups accounted for 92% of the birds encountered within the marsh during the census (Table 9). An additional 18 species were reported from the marsh by researchers and residents at other times during the duration of the study (Table 9).

The dominant waterfowl were American Black Ducks and Canada Geese; the dominant shorebirds were Semipalmated Plovers, Semipalmated Sandpipers, Least Sandpipers and Black-bellied Plovers; and the dominant gulls were Laughing Gulls (summer) and Bonaparte's and Ring-billed Gulls (winter). Shorebirds and waders were most abundant in late summer and early fall, waterfowl were predominant in the winter while gulls remained moderately aboundant throughout the period, but changed in species composition (Figure 15). These four classes of birds made up 96% of the species at Nonquitt marsh (Table 9), which would be expected in this wetland system.

Birds were not evenly distributed across zones (Figure 2; Table 10) either by class or by season. Detailed analysis of distribution of birds by zone is beyond the scope of this paper, but the data clearly shows that all three zones were utilized by many birds.

The identification of major habitat type (Appendix IV; Figures 1-8) used by the birds demonstrate that the unvegetated flats are of major importance to shorebirds, gulls and, to a lesser degree, waterfowl (Figure IV-1). The gulls used the unvegetated peat primarily as resting sites, but the shorebirds were actively foraging on the peat and mudflats. This suggests that there are sufficient invertebrates colonizing these sites to warrant feeding activity by a large number of shorebirds as they pass through during migration.

The drop in the number of waterfowl in January and especially February reflect a period when much of the open water was frozen. Some birds would rest on the ice (Figure IV-3), but the majority of waterfowl moved to other areas such as open fields or unfrozen salt ponds such as Allens Pond to obtain food.

The restriction of tidal flow and the die-back of vegetation has had mixed effects on utilization of the marsh by birds. The near fresh water condition that occurs in the marsh during the winter as rainwater is retained in the marsh, allows the open water to freeze earlier and for a longer period of time than it would if tidal flow were greater. This shortens the period of time throughout the winter that waterfowl can feed in the marsh. The die-back of salt marsh vegetation negatively impacts birds with life histories restricted to the salt marsh such as Seaside or Sharp-tailed Sparrows, but the die-back has apparently increased the amount of foraging habitat available for shorebirds. Thus, some classes of birds benefit from, while others suffer due to the changes that have occurred in the Nonquitt marsh.

Amphibians. Adult green frogs (Rana clamitans) and especially pickerel frogs (R. palustris) were commonly encountered in areas of the marsh dominated by fresh water vegetation and in the upper reaches of some of the mosquito ditches in the summer and early fall, 1988. Spring peepers (Hyla crucifer) were calling in the same areas in April, 1989. Since all these species are salt intolerant, their presence indicates that these areas of the marsh must be only very infrequently flooded by salt water.

Reptiles. Black racers (Coluber constrictor) were spotted twice during summer, 1988 in the marsh along the upland edge of the Spartina patens community. These are not wetlands animals, but were probably foraging for small marsh mammals such as voles. Snapping turtles (Chelydra serpentina) were also observed twice during the summer (probably the same individual) on the mud flats at the north end of the marsh. This animal is often seen in brackish water, so its presence is not surprising.

Mammals. A white-tailed deer (Odocoileus virginianus) was spotted in the west end of the marsh on August 17, probably foraging. Raccoon (Procyon lotor) tracks were observed on several occasions throughout the study along the edge of the creek and on the mud flats. Small mammals such as muskrats, voles, shrews and white-footed mice were undoubtedly present (Lee, 1986; Berkholtz, 1988) but not encountered during our study.

DISCUSSION AND RECOMMENDATIONS

Problems associated with inlet modification have been reviewed by Lee (1980). Local case studies (Giese, et al, 1981; Mello et al, 1987) have shown that numerous problems arise when large-scale modifications are undertaken in salt ponds. The underlying cause is the destabilization of the system. A salt pond is in a delicate equilibrium state regarding flow of water in and out of the pond, the physical features of the pond, and the assemblage of plants and animal communities within the pond. Alteration of flow within the system will affect all of the above as the system is knocked out of equilibrium and slowly progresses to a different equilibrium state (a process which can take decades). Often the "simple" answer to the problem, returning the salt pond to its original state, is not practically or even physically possible. Olsen & Lee (1982) present arguments for a practical approach to inlet management, where the goal is limited and small-scale alteration to maintain or return coastal pond systems to an equilibrium state.

A hundred-plus years ago, the marsh at Nonquitt was similar, albeit a little larger, in form and function to the present salt marsh system at Meadow Shores just west of Round Hill (Figure 3). As early as 1712, in the Benjamin Crane survey of Dartmouth (Hammond, B and S. Swift, 1910), the Nonquitt marsh is referenced, with areas described as "salt marsh", "swamp" and "bogg".

Today there are two major changes in the physical features of the marsh due to the relocation of the inlet and channel: a greatly restricted tidal flow and siltation of the former channel. This has resulted in the development of a tidal mudflat in the north end of the marsh which used to be open water. Dillon (1970) detailed patterns of sedimentation in salt ponds, showing that sedimentation was greater inside salt ponds that outside, and increasing the size of the inlet could increase siltation within the pond. With closure of the old inlet, flow has been greatly reduced in the former channel. Much of the far north end is a mudflat, and eventually, most of this entire section with also follow this pattern. Although this will result in a loss of open water habitat, our study has found that the current mudflats are rich foraging areas for migrating shorebirds; thus, this is not necessarily a negative impact.

There is photographic evidence as well as less precise evidence based on the 1856 map of the marsh (Figure 3) that there have been changes in vegetation. Former salt (or possibly brackish) marsh has been colonized by wetland shrubs and more recently, by colonization and expansion of both Phragmites and Typha. However, the major change in vegetation which has prompted this study, the die-back of nearly two-thirds of the marsh vegetation, has been a recent event.

The primary cause of the die-back appears to have been the waterlogging of the marsh soils due to periodic and irregular inundation prior to and culminating with the October, 1980 storm (Sears & Parker 1981, 1985) which created anoxic conditions in the sediment stressing the vegetation beyond its tolerance limits. However, the continued lack of significant revegetation is tied to both high soil salinity, particularly in depressions in the exposed peat, and continued waterlogging during the winter months (Figure 9) despite free flow through the culvert. What little recolonization by Spartina alterniflora has occurred is the result of progression of rhizomes from the borders of existing patches of vegetation or from direct planting (Parker & Sears, 1982; Sears & Parker, 1983).

Clearly, the most crucial management aspect regarding the Nonquitt marsh is to reduce the unpredictability in the flooding of the unvegetated peat so that it can be recolonized by marsh vegetation. Based upon the salinity of the water flooding the marsh (Appendix III), it is primarily fresh water derived from rainfall that is being dammed in the marsh; however, flooding during spring tides also may cover the marsh for nearly the entire tidal cycle for a few consecutive days (Figures 7-9). Thus, increased flow out of the marsh, particularly during the fall and winter months, is crucial if significant recolonization is to occur.

In order to reach the goal of restoration of vegetation within the marsh, we make the following recommendations.

1. The channel under the road should be as deep and as wide as necessary so that there is o impediment to flow at this juncture. This study has demonstrated that presently there is a restriction of flow due to an obstruction in the channel and the reduced size of the opening under the bridge. This is having a dam ng effect on the marsh side of the channel.

2. Water lev in the marsh sh d be monitored on a dai basis (preferably with a tide record after the bridge repair in order to determine whether flow has incr sed enough so that the unvegetated peat does not remain flooded several days in a row after spring tides or heavy rains. Water level should be monitored in the channel immediately west of the bridge and also west of the flood tidal delta to determine if this will now be a point of restricted flow.

3. Regular inspection of the culvert should be undertaken, epsecially after storms or extremely high tides so that it remains free-flowing at all times.

4. It would be expedient to file a Notice of Intent with the Conservation Commission or work out some other arrangement so that flow may be maintain in the channel. Since the flood tidal delta is composed largely of organic matter (decaying algae and eelgrass), restriction of flow in the channel may occur when a section of the delta shifts location after a storm. This, as well as blockage from materials coming in through the culvert, may restrict flow out of the marsh. A mainter ermit or agreemer ould allow quick

action after storms or other events which may result in restriction of flow in the channel rather than the pipe.

5. Interstitial soil salinity as well as water salinity within the marsh should be monitored weekly on a year-round basis to determine the feasibility of replanting Spartina on a large scale within the marsh.

6. Transects initiated by Sears should be monitored to determine their current status.

7. If enlargement of the channel during reconstruction of the bridge does not provide sufficient flow to drain the unvegetated peat after heavy rains, spring tides or storm events, any corrective measures will be costly and will involve significant permitting obstacles. This includes any of Metcalf & Eddy's Solution Alternatives (1983). Before further action is contemplated, Nonquitt residents should reach a concensus on what direction to pursue, and they should maintain close contact with Dartmouth Conservation Commission regarding any alteration of the channel.

8) Mtecalf & Eddy's third alternative, replacement of the open channel with a piped system is not recommended. Problems with blockage in the current pipe over the past ten years indicates that increasing the length of pipe can only create more blockage problems. An open channel is easier to maintain than an enclosed pipe, even if fitted with removable caps.

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Figure 1. Preliminary base map of the Nonquitt salt marsh with locations of transects (A-Z), water sampling stations (1-8), tide staffs (S_1-S_3) and osprey platform (⊕).

(from Sears & Parker, 1981)

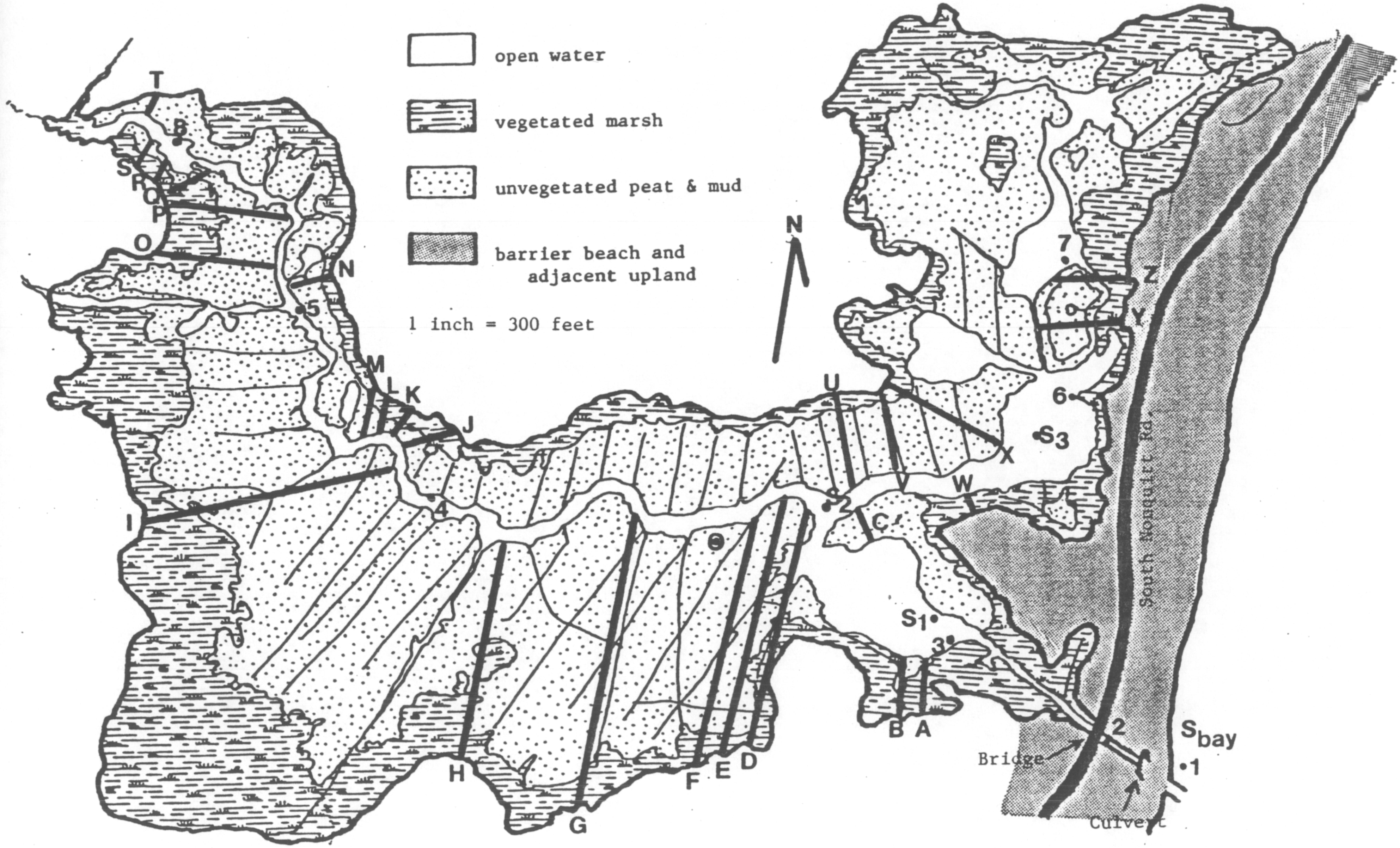
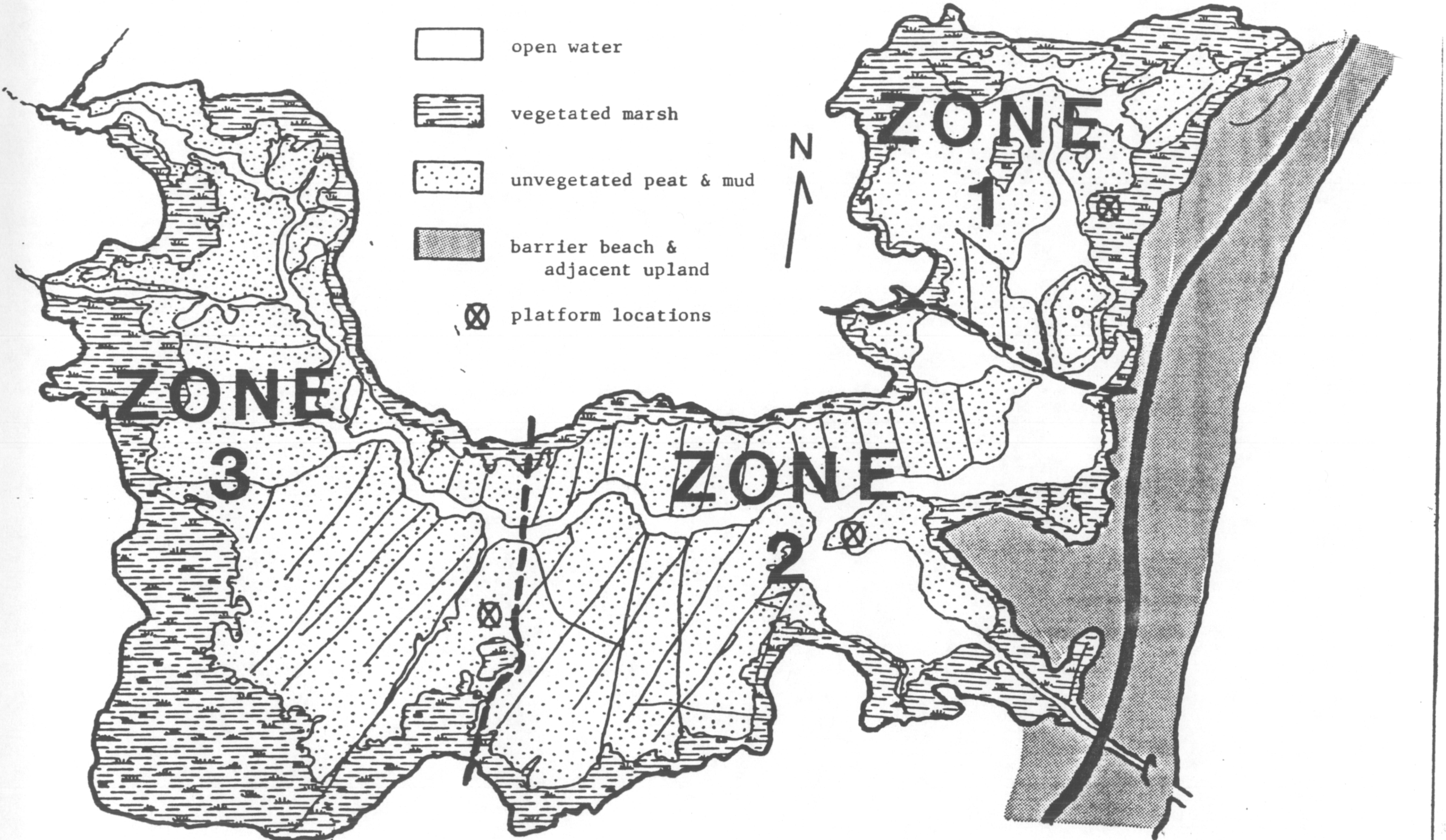


Figure 2. Location of zones and platforms within the marsh for the bird census.



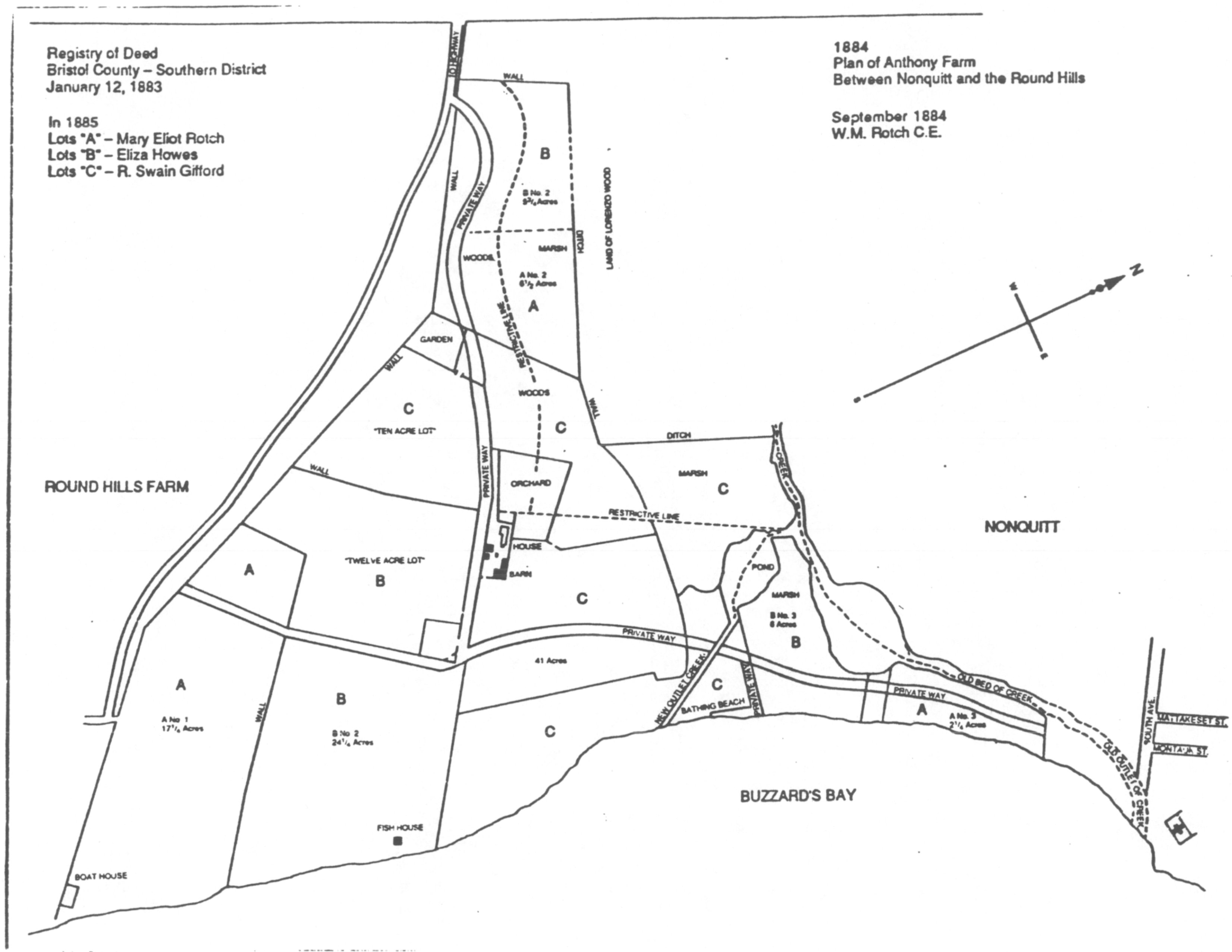


Figure 6. Lot plan, South Nonquitt, 1884 - showing the location of the new outlet.

Figure 7. Tidal cycle at Nonquitt for the bay, culvert and bridge stations on August 5-6, 1988.

(actual time: 0 = 0740 hrs.)

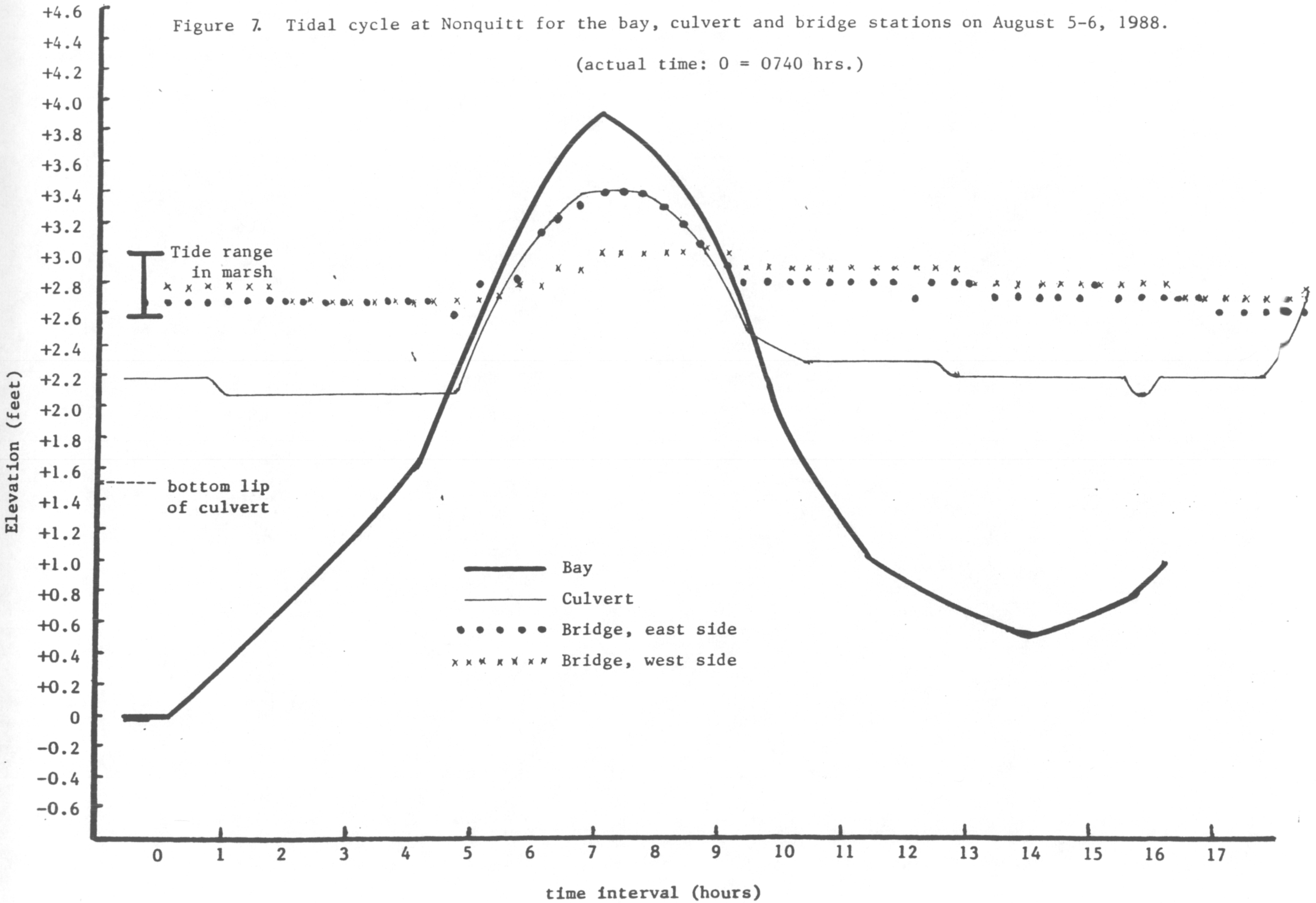


Figure 8. Tidal cycle at Nonquitt for the bay, culvert and bridge stations on August 29, 1988.

(actual time: 0 = 0310 hrs.)

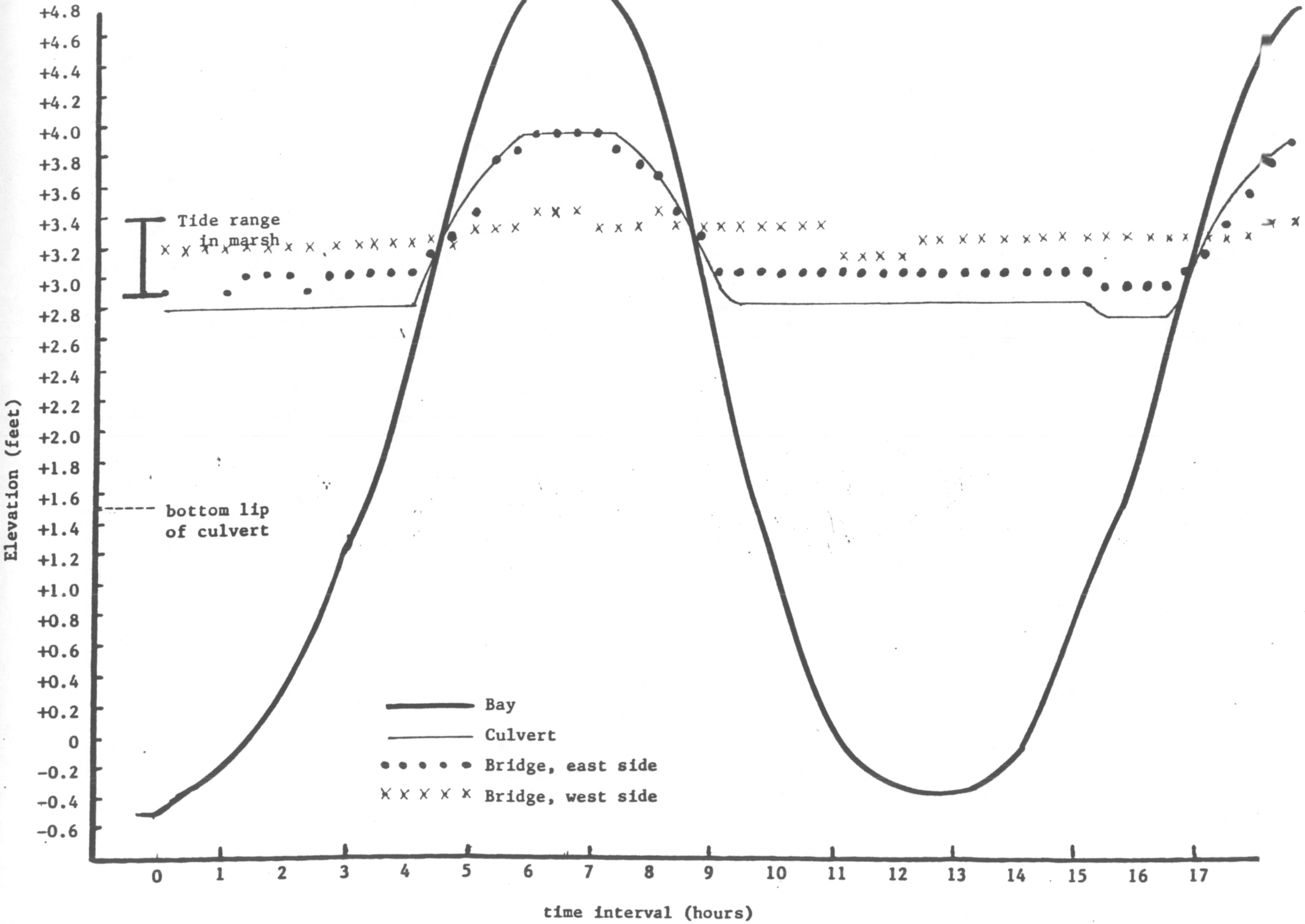


TABLE 3. NONQUITT SALTMARSH--- Ph

Sta.#		1	2	3	4	5	6	7	8
Sept.	23	8.0	8.0	8.0	8.5	8.0	8.0	8.5	7.5
	26	7.2	8.2	8.0	8.4	8.2	9.2	4.8	3.6
Oct.	03	8.0	7.5	8.0	7.5	7.5	7.5	---	7.5
	07	8.2	8.3	8.3	8.2	7.7	8.4	---	7.0
	10	8.5	8.5	8.0	8.0	8.0	8.0	8.0	7.5
	14	8.0	8.0	8.5	8.5	7.5	8.0	8.5	7.0
	19	8.5	8.5	8.5	8.5	8.0	8.5	---	---
	21	8.5	8.0	8.5	8.0	8.0	8.5	---	7.0
	24	8.5	8.5	8.0	8.0	7.5	8.0	8.0	7.0
	28	8.0	8.0	8.5	8.5	8.0	8.0	8.0	7.0
Nov.	02	8.5	7.5	7.5	7.5	7.0	7.5	7.0	6.5
	04	8.5	7.5	---	7.0	6.5	7.5	---	---
	09	8.5	8.0	8.0	8.5	7.5	8.0	8.0	6.5
	14	8.5	8.5	8.5	7.5	7.0	7.5	8.5	6.5
	18	8.5	8.5	7.5	7.5	7.0	7.5	7.0	6.0
	23	8.5	7.0	7.0	6.5	6.5	7.0	6.0	6.0
	28	8.0	8.5	7.5	7.0	5.5	6.0	6.0	5.5
Dec.	02	8.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5
	05	8.5	7.0	---	5.5	5.5	6.0	---	6.0
	09	8.5	8.0	7.5	7.5	6.0	7.0	6.5	5.5
	12	8.0	8.5	8.0	8.0	---	7.0	7.0	6.5
	15	8.5	8.0	8.5	8.0	7.0	7.5	7.5	6.0
	28	8.5	8.5	7.5	7.5	6.5	7.0	---	5.5
Jan. 1989	06	8.5	8.0	---	6.0	6.5	7.0	---	6.5
	10	8.0	8.0	8.5	6.5	6.5	7.0	7.0	6.5
	13	8.5	7.5	7.5	7.0	6.5	7.0	7.0	6.5
	20	8.5	8.0	8.0	7.0	6.5	7.0	7.0	6.5
	26	8.5	8.5	8.0	6.5	6.5	7.0	7.0	6.5
Feb.	07	8.0	8.5	8.0	7.5	7.0	8.0	7.0	6.5
	14	8.0	7.0	7.0	---	6.5	7.0	7.0	6.5
	21	8.5	8.5	8.0	7.0	6.5	7.0	7.0	6.5
Mar.	02	8.5	7.0	---	6.5	---	6.5	---	6.5
	09	8.0	7.5	7.5	6.5	6.5	8.0	7.0	6.5
	14	8.5	7.5	7.5	6.5	6.5	7.0	7.0	6.5
	20	8.0	6.5	6.5	6.5	6.5	7.0	7.0	6.5
	28	8.0	7.0	7.0	6.5	6.5	7.0	7.0	6.5

Station 1 - Bay
Station 2 - Channel, at the bridge
Station 3 - Head of channel, the flood tidal delta
Station 4 - Mid-creek, between transects H & I
Station 5 - Upper creek, near transect N
Station 6 - North pond
Station 7 - North creek, former channel
Station 8 - Upper reaches of west creek

TABLE 4. TOTAL ALKALINITY in Mg/L as $CaCo_3$

	Sta.#	1	2	3	4	5	6	7	8
1988 Sept.	23	134	116	117	078	121	105	103	061
	26	115	123	128	116	128	138	110	137
	30	104	127	115	111	133	139	136	128
Oct.	03	173	157	121	154	142	130	---	112
	07	147	123	118	131	133	138	---	095
	10	121	111	118	108	113	123	092	089
	14	145	116	115	123	098	118	124	089
	19	122	139	119	130	109	180	---	---
	21	162	144	140	130	137	172	---	149
	24	151	134	103	134	104	112	080	052
	28	123	130	103	105	105	112	077	080
Nov.	02	137	160	107	123	108	082	108	135
	04	107	076	---	077	079	081	---	---
	09	128	098	107	099	116	104	075	082
	14	127	121	134	101	076	073	083	049
	18	128	125	073	070	050	053	047	024
	23	128	080	051	053	054	048	029	026
	28	091	114	073	084	055	102	053	033
Dec.	02	101	025	035	022	032	023	025	022
	05	154	028	---	027	028	023	---	025

Station 1 - Bay

Station 2 - Channel, at the bridge

Station 3 - Head of channel, the flood tidal delta

Station 4 - Mid-creek, between transects H & I

Station 5 - Upper creek, near transect N

Station 6 - North pond

Station 7 - North creek, former channel

Station 8 - Upper reaches of west creek

TABLE 5. NONQUITT SALTMARSH---DISSOLVED OXYGEN (ppm)

Sta.#		1	2	3	4	5	6	7	8
	23	---	---	8.8	---	6.3	6.2	10.2	8.5
	26	7.2	8.2	8.0	8.4	8.2	4.8	9.2	3.6
	30	7.8	8.6	7.2	4.6	3.4	5.8	6.4	3.8
Oct.	03	7.2	3.2	9.0	4.4	7.0	7.2	nw	6.4
	07	8.0	8.0	4.2	8.0	3.8	7.4	nw	nw
	10	9.0	8.0	7.8	8.8	9.0	9.0	7.2	6.2
	14	7.6	9.0	8.2	10.2	7.8	7.4	7.4	3.2
	19	5.6	6.6	8.8	7.2	7.0	6.8	nw	nw
	21	5.4	7.5	8.0	7.2	8.2	9.4	nw	7.6
	24	6.8	8.2	8.4	9.6	9.2	8.0	7.4	6.0
	28	7.0	9.4	10.2	7.2	9.2	10.2	7.8	7.0
Nov.	02	6.4	9.8	10.0	11.0	11.2	10.0	6.6	5.8
	04	9.0	9.0	nw	9.4	8.4	10.0	nw	nw
	09	8.2	11.2	10.4	9.4	6.4	9.8	7.8	5.2
	14	6.4	7.4	6.4	8.6	8.2	9.0	8.0	7.8
	18	8.8	7.8	9.0	8.0	6.2	10.2	7.4	4.6
	23	11.0	9.0	9.0	10.0	6.8	9.4	6.2	5.8
	28		8.0	9.0	9.0	6.8	7.6	6.2	5.6
Dec.	02	7.0	7.8	8.4	8.4	7.2	8.0	6.2	3.0
	05	11.0	10.0	nw	9.4	6.0	3.2	nw	5.8
	09	5.8	4.8	5.2	4.8	7.4	6.0	6.0	7.8
	12	5.6	8.8	5.2	6.0	ice	7.0	7.0	6.5
	15	5.4	6.8	6.8	7.6	10.2	10.0	8.4	8.4
	28	5.8	6.0	6.6	8.4	8.6	10.0	nw	10.2
1989 Jan.	06	5.6	3.6	ice	9.8	6.0	9.2	ice	7.6
	10	7.0	6.8	9.8	9.0	8.0	10.0	7.6	7.4

Station 1 - Bay

Station 2 - Channel, at the bridge

Station 3 - Head of channel, the flood tidal delta

Station 4 - Mid-creek, between transects H & I

Station 5 - Upper creek, near transect N

Station 6 - North pond

Station 7 - North creek, former channel

Station 8 - Upper reaches of west creek

Table 6. Frequency of occurrence of vegetation within each major plant community defined by dominant species.
(Communities: PE = unvegetated peat/silt or macroalgae; SA = *Spartina alterniflora*; SP = *Spartina patens*; TY = *Typha angustifolia*; SC = *Scirpus* spp.)

SPECIES	frequency of occurrence/sample X 100% PE	SA	SP	TY	SC	Total	total samples
Spartina alterniflora Salt Marsh Cordgrass	7.2	96.7	49.4	5.4	26.7	18.1	356
Spartina patens Salt Hay	1.0	31.7	80.0	15.2	35.9	14.3	282
Eleocharis parvula Dwarf Spike-rush	15.0	12.5	0.6	0.6	31.8	14.1	277
Salicornia europaea Common Glasswort	15.4	20.0	2.4		1.5	11.9	234
Pluchea purpurascens Salt Marsh Fleabane	0.4	40.8	32.4	20.6	32.3	10.5	206
Scirpus americanus Three-square Sedge	0.4	8.3	45.3	6.1	50.8	10.2	201
Typha angustifolia Narrow-leaved Cattail	0.2	0.8	4.1	97.6	12.3	10.0	196
Lythrum salicaria Purple Loosestrife		10.8	12.4	30.9	30.2	7.3	144
Scirpus paludosus Bayonet Grass	1.1	8.3	1.8	1.2	30.8	4.6	90
Dryopteris thelypteris Marsh Fern	0.4		6.5	16.4	16.4	3.8	75
Toxicodendron radicans Poison Ivy	0.5		6.5	5.4	16.4	3.0	59
Aster spp. Aster spp.	0.3	1.7	7.6	6.7	14.4	2.9	58
Agrostis sp. Bent-grass sp.		0.8	4.1	3.6	14.4	2.1	42
Solidago tenuifolia Slender-leaved Goldenrod	0.2		17.6		5.1	2.1	42
Sonchus arvensis Sow Thistle				19.4	1.0	1.7	34
Hibiscus palustris Rose Mallow	0.1	0.8	1.2	16.4		1.6	31
Ptilimnium capillaceum Mock Bishop's Weed		2.5	0.6	14.6	1.0	1.5	30
Myrica gale Sweet Gale			2.9		11.8	1.4	28
Panicum virgatum Switchgrass			11.2		2.6	1.2	24
Rosa palustris Swamp Rose	0.2		6.5		5.6	1.2	24
Spartina pectinata Fresh-water Cordgrass			4.1		8.2	1.2	23
Gramineae spp. Grass spp.			0.8	3.5	1.2	1.1	21

Table 6. cont.

SPECIES	PE	SA	SP	TY	SC	Total	total samples
	frequency of occurrence/sample X 100%						
Distichlis spicata Spike Grass			11.2		0.5	1.0	20
Sphagnum sp. Sphagnum Moss				7.3	3.6	1.0	19
Eleocharis rostellata Beaked Spike-rush			0.6	0.6	7.7	0.9	17
Dryopteris simulata Massachusetts Fern			5.9		3.1	0.8	16
Juncus canadensis Canada Rush					6.7	0.7	13
Hypericum virginicum Marsh St. John's-wort			0.6	4.9	1.0	0.6	11
Phragmites communis Reed			2.4	3.6		0.5	10
Clethra alnifolia Sweet Pepperbush					4.1	0.4	8
Solidago sempervirens Seaside Goldenrod			2.9		1.0	0.4	7
Lycopus virginicus Water Horehound			0.6	3.6		0.4	7
Scirpus robustus Salt Marsh Bulrush	0.1				2.6	0.3	6
Carex sp. Sedge sp.					2.6	0.2	5
Cladium mariscoides Twig Rush			1.2		1.0	0.2	4
Cyperus sp. 2 Umbrella Sedge sp. 2		0.9			1.5	0.2	4
Myrica pensylvanica Bayberry			1.8		0.5	0.2	4
Acer rubrum Red Maple					2.0	0.2	4
Cyperus sp. 1 Umbrella Sedge sp. 1					1.5	0.2	3
Atriplex patula Marsh Orach		0.9		1.2		0.2	3
Vaccinium macrocarpon Large Cranberry					1.0	0.1	2
Iva fructescens Salt Marsh Elder		1.7				0.1	2
Drosera intermedia Spatulate-leaved Sundew					1.0	0.1	2
Galium tinctorium Dye Bedstraw				1.2		0.1	2
Impatiens capensis Jewelweed				0.6		0.1	1

Table 6. cont.

SPECIES	frequency of occurrence/sample X 100% PE	SA	SP	TY	SC	Total	total samples
<u>Onoclea</u> <u>sensibilis</u> Sensitive Fern					0.5	0.1	1
<u>Spergularia</u> <u>marina</u> Salt Marsh Sand Spurrey	0.1					0.1	1
<u>Limonium</u> <u>nashii</u> Sea Lavender		0.9				0.1	1
Misc. spp.	0.2	3.3	2.4	4.2	7.7	1.6	32
TOTAL SAMPLES	1320	120	170	165	195		1970

Table 7. Relative abundance of vegetation within each major plant community defined by dominant species.
(Communities: PE = unvegetated peat/silt or macroalgae; SA = *Spartina alterniflora*; SP = *Spartina patens*; TY = *Typha angustifolia*; SC = *Scirpus* spp.) * = less than 0.1%

SPECIES	relative abundance (f X 100%) by # squares PE	SA	SP	TY	SC	Total	total squares
Spartina patens Salt Hay	5.0	17.9	42.7	11.2	16.9	21.0	6211
Spartina alterniflora Salt Marsh Cordgrass	15.4	55.9	14.7	3.1	4.0	15.8	4690
Eleocharis parvula Dwarf Spike-rush	47.0	5.9	0.1	0.1	13.0	11.6	3436
Scirpus americanus Three-square Sedge	1.2	2.3	16.6	1.5	18.7	10.6	3131
Typha angustifolia Narrow-leaved Cattail	0.4	0.2	0.6	39.4	1.6	6.9	2040
Scirpus paludosus Bayonet Grass	3.4	2.1	0.3	1.1	11.0	4.3	1287
Pluchea purpurascens Salt Marsh Fleabane	1.0	8.3	3.1	6.2	3.8	4.2	1258
Salicornia europaea Common Glasswort	20.6	4.6	0.2		0.3	3.7	1103
Lythrum salicaria Purple Loosestrife		1.4	1.0	6.4	3.6	2.6	755
Toxicodendron radicans Poison Ivy	2.7		0.3	1.9	4.7	2.2	641
Dryopteris thelypteris Marsh Fern	1.2		1.4	4.3	2.1	1.8	542
Distichlis spicata Spike Grass			5.4		0.2	1.4	417
Spartina pectinata Fresh-water Cordgrass			1.6		3.3	1.4	409
Panicum virgatum Switchgrass			4.0		0.7	1.2	361
Eleocharis rostellata Beaked Spike-rush			0.1	0.5	3.3	1.1	324
Agrostis sp. Bent-grass sp.		0.5	0.2	1.3	2.4	1.1	320
Ptilimnium capillaceum Mock Bishop's Weed		0.2	*	6.5	*	1.1	314
Aster spp. Aster spp.	0.6	0.1	0.8	1.7	1.5	1.0	305
Sonchus arvensis Sow Thistle				5.8	*	0.9	273
Solidago tenuifolia Slender-leaved Goldenrod	0.1		2.4		1.0	0.9	272
Myrica gale Sweet Gale			0.5		2.2	0.8	231
Sphagnum sp. Sphagnum Moss				3.6	0.3	0.6	189

Table 7. cont.

SPECIES	PE	SA	SP	TY	SC	Total	total squares
	relative abundance (f X 100%) by # squares						
Rosa palustris Swamp Rose	0.5		1.0		0.7	0.5	158
Hibiscus palustris Rose Mallow	*	*	*	2.7		0.4	132
Gramineae spp. Grass spp.		0.2	0.5	0.2	0.9	0.4	128
Scirpus robustus Salt Marsh Bulrush	0.5				1.0	0.4	108
Dryopteris simulata Massachusetts Fern			0.7		3.0	0.3	80
Phragmites communis Reed			0.3	1.0		0.2	71
Juncus canadensis Canada Rush					0.7	0.2	60
Carex sp. Sedge sp.					0.4	0.1	35
Solidago sempervirens Seaside Goldenrod			0.3		0.1	0.1	32
Lycopus virginicus Water Horehound			*	0.6		0.1	29
Hypericum virginicum Marsh St. John's-wort			*	0.5	*	0.1	29
Cladium mariscoides Twig Rush			0.3		*	0.1	27
Clethra alnifolia Sweet Pepperbush					0.3	0.1	25
Myrica pensylvanica Bayberry			0.2		0.1	0.1	21
Vaccinium macrocarpum Large Cranberry					0.2	0.1	19
Cyperus sp. 1 Umbrella Sedge sp. 1					0.2	0.1	15
Atriplex patula Marsh Orach		0.1		0.1		*	6
Iva fructescens Salt Marsh Elder		0.1				*	6
Cyperus sp. 2 Umbrella Sedge sp. 2		*			0.1	*	6
Acer rubrum Red Maple					*	*	4
Drosera intermedia Spatulate-leaved Sundew					*	*	3
Galium tinctorium Dye Bedstraw				*		*	2
Impatiens capensis Jewelweed				*		*	1

Table 7. cont.

SPECIES	relative abundance (f X 100%) by # squares PE	SA	SP	TY	SC	Total	total squares
Onoclea sensibilis Sensitive Fern					*	*	1
Spergularia marina Salt Marsh Sand Spurrey	*					*	1
Limonium nashii Sea Lavender		*				*	1
Misc. spp.	0.3	0.1	0.6	.02	0.8	0.5	141
TOTAL SQUARES	4275	4354	7490	4632	8899	-	29,650

* less than 0.1%